

## UNDERGROUND PIPE AND METHOD OF SECURING CONDUITS

### BACKGROUND OF THE INVENTION

This invention relates to improvements in methods of and in means for laying cables, conductors, hoses and similar parts in existing underground pathways including those defined by sewage pipes, water pipes, gas pipes and the like.

The laying of data-transmitting and/or other cables and the like (hereinafter referred to as cables for short but intended to encompass all other suitable information-transmitting and/or analogous systems) in inhabited regions, especially in cities, often involves huge expenditures in time, labor, parts and money. This also includes those recent proposals according to which data transmitting cables and the like are installed in existing sewage pipes, water pipes and the like. Certain prior proposals include the utilization of various clamps or analogous fasteners which are employed to directly secure a cable in an existing underground pipe (such as a sewage pipe). The establishment of connections between a cable and the interior of a sewage pipe or the like, normally or frequently by mechanical means, necessitates resort to skilled labor, to numerous prefabricated parts and temporary exposure of large portions of an underground pipe all of which contributes to the cost of such work and to lengthy interruptions of use of the pipe.

An underground sewage pipe must be cleaned, preferably at frequent intervals, in order to counteract the mechanical and/or chemical stressing of the pipe by confined sewage. Such cleaning normally or frequently involves the utilization of brushes and/or other mechanical cleaning implements as well as or the resort to jets of water and/or other fluid(s). These undertakings are likely to result in damage to or in the destruction of cables in the sewage pipes, water pipes or the like. Therefore, it is often preferred to resort to other modes of treating the internal surfaces of sewage pipes and the cables which are confined therein. One presently known undertaking other than the utilization of clamps is disclosed in the commonly owned US patent No. 6,572,306 B2 which proposes the utilization of an expandible tubular liner consisting of or containing a hardenable material and being introduced into the sewage pipe to be thereupon expanded in order to urge the previously inserted cable or cables against the internal surface of the pipe. Such proposal exhibits the advantage that the inserted, expanded and hardened liner protects the cable(s) and the pipe against direct contact with the sewage as well as that the liner forms part of and reinforces the thus repaired pipe while simultaneously preventing the establishment of any contact between

the cable or cables and the flowing sewage.

Another important advantage of the just outlined patented undertaking is that it can serve several purposes such as repairing a damaged sewage pipe and preventing the sewage from contacting the cable(s) in the pipe. However, if the liner is to be employed solely to shield the cable(s) from direct contact with sewage in the piping, such undertakings are often considered to be too expensive, for example, in cities or certain parts of cities or towns wherein the budget for such types of work is often very limited.

Commonly owned International patent application Serial No. WO 00/06843 (published February 10, 2000) proposes to embed data-transmitting cables or tubes containing such cables in a strip-shaped carrier which is made of a textile material, such as knitted fabric, and is affixed to a selected portion of the internal surface of a sewage pipe or the like. The strip-shaped carrier includes a hardenable matrix, e.g., an epoxy resin, and is introduced into the sewage pipe by a camera-carrying robot to be thereupon pressed against the internal surface of the pipe by resorting to an expandible hose containing a stream of flowing heating fluid, e.g., hot water. The stream is caused to flow in the hose for a period of several hours which is necessary to ensure sa-

tisfactory hardening of the matrix and to thus establish a non-separable connection between the expanded hose and the pipe. The hose is thereupon withdrawn from the pipe.

A drawback of the just described proposal in the International patent application Serial No. WO 00/06843 is that the installing of the strip-shaped carrier in the sewage pipe is very expensive. This will be readily appreciated by considering that the installing of a carrier having a length of 200 meters in a sewage pipe having a diameter of one meter necessitates the utilization of approximately 160,000 liters of hot water which cannot be reused, primarily because it is practically impossible to provide one or more reservoirs or other storage facilities which would be capable of confining such huge quantities of water during the intervals between the insertions of two successive strips of hardenable carrier material.

## OBJECTS OF THE INVENTION

An important object of the present invention is to provide a novel and improved method of installing one or more gas, fluid, current and/or information transmitting conduits in the interior of an underground sewage pipe, water pipe, gas pipe or the like at a fraction of the cost of presently known methods.

Another object of the invention is to provide a novel and improved method of reliably securing one or more conduits in an underground sewage pipe or the like.

A further object of the instant invention is to provide a novel and improved method of ensuring an optimal setting of materials which are utilized to position and retain one or more cables in a sewage pipe, a water pipe, a gas pipe or the like.

An additional object of the invention is to provide an underground pipe, such as a sewage pipe, a water pipe or a gas pipe, containing one or more conduits for the confinement of one or more cables, conduits, conductors or the like which are introduced into and held in the pipe in accordance with the method of the invention.

Still another object of the instant invention is to provide a novel and improved method of introducing one or more conduits into and of reliably locating such

conduit(s) in an existing (previously laid) underground pipe.

A further object of the invention is to simplify and render less expensive the laying of individual or plural conduits in underground pipes for sewage, water, gases or the like.

An additional object of the invention is to enhance the versatility of existing underground pipes for sewage or the like.

## SUMMARY OF THE INVENTION

One feature of the present invention resides in the provision of a method of effecting a setting or hardening of a heat-hardenable matrix in at least one at least substantially strip-shaped elongated carrier which preferably consists of a textile or analogous material, which confines at least one conduit and which is adjacent the internal surface of a pipe of the type adapted to be embedded (and normally embedded) in the ground to convey sewage, water, gases or the like. The improved method comprises the step of conveying through the at least one conduit a gaseous or hydraulic fluid at a temperature which suffices to effect a setting of the matrix. The at least one conduit can confine at least one data carrier, current conductor or one or more other solid bodies, or a stream or temporarily stagnant body of liquid or gaseous fluid.

The method preferably further comprises the step of pressing the at least one carrier against the internal surface of the pipe prior to the fluid conveying step. The fluid can consist of hot water, hot vapors or any other suitable heatable medium which can be conveyed through the conduit or conduits in the carrier.

The conveying step can include causing the fluid to flow at least once in a first direction from one to

the other end and at least once in a second direction from the other end to the one end of the elongated carrier.

The carrier can confine a plurality of conduits and the conveying step then preferably includes causing the fluid to flow from one to another end of one of the conduits, thereupon from the other end of the one conduit into one end of another of the plurality of conduits, and thereafter from the one end to the other end of the other conduit.

The improved method can also comprise the step of urging the at least one carrier against at least one selected portion of the internal surface of the pipe; such urging step can include introducing into the pipe a radially expansible hose and inflating the hose in the pipe to thus urge the carrier against the at least one selected portion of the internal surface of the pipe. Alternatively (or even in addition to utilization of the hose), the method can comprise the step of pressing the at least one carrier against the internal surface of the pipe, at least prior to the fluid conveying step, by urging at least one panel (such as a board, plate or the like) against the carrier in the pipe. Such pressing step can include compressing the at least one carrier between the at least one panel and the internal surface



of the pipe in the course of the aforementioned conveying step.

If the urging step is carried out by resorting to a radially expandible hose which is inflated in order to urge the carrier against the internal surface of the pipe, the step of introducing the hose into the pipe can include employing at least one mobile robot which is caused to invert the hose during advancement of the robot in and lengthwise of the pipe. The robot can include at least one arm or the like which is releasably secured to a front end of the hose prior to advancement of the robot in the pipe.

Another important feature of the present invention resides in the provision of an underground structure which comprises (a) an elongated pipe having an internal surface and being arranged to convey a flow of a substance including sewage, water, gas or the like, (b) at least one elongated at least substantially strip-shaped carrier which is adjacent the internal surface of the pipe and includes a heat-hardened matrix and at least one conduit extending at least substantially lengthwise of the pipe, and (c) means for urging the at least one carrier against the internal surface of the pipe. The matrix is hardened as a result of conveying (once or more than once) at least one stream of a heated

gaseous or liquid fluid in the at least one conduit longitudinally of the pipe.

The carrier can be provided with a plurality of conduits which preferably extend at least substantially lengthwise of the pipe, and such underground structure preferably further comprises means (e.g., a looped portion of a pipe or hose) for connecting one end of one of the conduits with one end of another conduit of the plurality of conduits, and means (such as an electric heater or the like) for admitting the stream of heated fluid into the other end of the one conduit so that the thus admitted fluid flows through the one conduit, thereupon through the connecting means and thereafter through the other conduit counter to the direction of fluid flow in the one conduit. The aforementioned means for urging can comprise the aforesaid radially expanded hose in the pipe and/or the aforementioned panel or panels in the pipe.

In all embodiments of the present invention, the pipe can consist of a material which is selected from the group consisting of concrete, a plastic material, a metallic material and a ceramic material. Combinations of two or more different materials can be employed with equal or similar advantage.

If the pipe is laid in the ground in such a way

that its internal surface includes an apex portion, the at least one carrier can be inwardly adjacent the apex portion of the internal surface. However it is equally possible to install the at least one carrier adjacent another portion of the internal surface of the pipe, e.g., adjacent a lateral portion or the bottom portion of such internal surface. It is also possible to provide the pipe with two or more internal carriers each of which is provided with one or more conduits.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved pipe itself, both as to its construction and the methods of assembling, installing and utilizing the same, together with numerous additional important and advantageous features and attributes thereof, will be best understood upon perusal of the following detailed description of certain presently preferred specific embodiments with reference to the accompanying drawing.

### BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a fragmentary perspective view of a pipe, such as a sewage pipe in a city, which contains a strip receiving two parallel conduits and being installed in accordance with one presently preferred embodiment of the method of the invention;

Fig. 2 is a schematic view of a row of buildings adjacent to an underground sewage pipe or the like which is about to confine or already confines at least one strip similar to or identical with that shown in Fig. 1 and extending between two ducts which can serve to afford access to the respective ends of the pipe;

Fig. 3 is a somewhat enlarged view of a portion of the pipe between the underground ducts in the arrangement which is shown in Fig. 2; and

Fig. 4 is an enlarged longitudinal sectional view of the pipe and illustrates one presently preferred mode of introducing into the pipe an elongated deformable hose which serves to temporarily urge the strip or strips against the internal surface of the pipe.

### DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to Fig. 1, the reference character 1 denotes a conduit or pipe (hereinafter called pipe for short) which can be made of steel, concrete, a ceramic material, a plastic material or any other substance which is suitable to properly confine a stagnant or flowing body of sewage, water, gas or another fluid or flowable medium. The apex or top portion S of the pipe 1 is internally lined with a longitudinally extending strip-shaped carrier 4 having a sickle-shaped cross-sectional outline and consisting of a woven or knit textile material or the like. In the embodiment of Fig. 1, the strip 4 confines two spaced-apart parallel or substantially parallel conduits 5 which can receive communication-transmitting cables, electrical conductors, streams of a liquid substance, streams of a gaseous medium or the like (not shown in Fig. 1). The means for urging the strip 4 against the internal surface 9 of the pipe 1 comprises an at least radially expandible hose 7 which confines a body of compressed air during the interval which is required to complete the installation of the strip 4 at the inner side of the apex S of the pipe 1.

It will be appreciated that the mounting of the strip 4 at the apex S of the pipe 1 constitutes but one

of several possible positionings of such strip and of the conduit(s) 5 therein. For example, the strip 4 (or a second strip, not shown) can be placed adjacent the lateral portion R and/or adjacent the bottom portion T of the internal surface 9 of the pipe 1. The single strip 4 (or each of two or more discrete strips) can be temporarily secured to the respective portion of the internal surface 9 of the pipe 1 in any suitable manner not forming part of the present invention (e.g., with the aforementioned clamps or analogous fasteners) or by the arm (8) of a suitable robot (e.g., a device of the type shown in Fig. 4, as at 6). Such temporary securing of the strip(s) 4 in an optimum position is particularly advisable if the strip(s) 4 must be guided around and/or into one or more lateral outlets or branch pipes (one shown in Fig. 2, as at 11) which communicate with the (main or primary) pipe 1 and serve to guide one or more cables and/or conduits into selected or successive buildings or residences M adjacent a street or avenue or alley in a city, a town or another settlement.

The preferably textile strip 4 is permeated with a suitable heat-hardenable or settable resin which constitutes a matrix 3. Such permeation can take place prior to introduction of the strip 4 into the pipe 1, e.g., by resorting to the aforementioned robot 6 which

can introduce the strip 4 into the pipe and can also serve to properly locate the strip(s) in the pipe (such as at S, R and/or T). The expandible hose 7 is preferably introduced into the pipe 1 immediately or shortly after insertion of the strip(s) 4, for example, by resorting to an inverting or clinching or similar or analogous undertaking. For example, the insertion of the hose 7 can involve an inversion of successive increments of the hose in a direction from the inlet toward the outlet of the pipe 1; this ensures that successive increments of the hose 7 are caused to lie against successive increments of the strip 4 without any (or without appreciable) lateral and/or longitudinal movement between them. The introduction of the strip 4 is effected by resorting to a stream of a suitable fluid (such as blown-in air or pumped-in water) which assists the arm 8 of the robot 6. The arrangement is or can be such that the pressure of fluid which is being introduced into the hose 7 suffices to ensure reliable and uniform biasing of the external surface of the hose against the adjacent portions of the non-overlapped part of the internal surface 9 of the pipe 1 as well as against the internal surface(s) of the strip(s) 4. This is shown in Fig. 4 wherein the arrows further indicate the directions of advancement of the robot 6 and its arm 8 as well as the

direction of progressive inversion of successive increments of the hose 7.

Once the hose 7 is properly introduced into the pipe 1 and urges the strip(s) 4 against the selected portion(s) (such as S, R and/or T) of the internal surface 9 of the pipe 1 while maintaining the interior of the hose 7 at an optimum pressure, each conduit 5 in the strip 4 receives a stream or flow of heated fluid (e.g., steam or water) which is introduced by way of a first underground duct A and flows toward a second underground duct B. The former duct (A) confines those portions of the two conduits 5 which are connected to a heating device 13 for the fluid in the conduits 5, and the latter duct (B) receives a looped portion of a pipe or hose 15 which connects the respective end portions of the two conduits with each other.

The heating device 13 can be operated with electric current, with gas and/or in any other suitable manner. The length L of the pipe 1 between the ducts A and B can vary within any desired range because the volume of the fluid in the conduits 4 between the ducts A and B is practically negligible in comparison with the volume of the pipe 1 between such ducts, i.e., the expenditures involving adequate heating of fluid (such as air or water) in these conduits are but a minute fraction



of the cost involving the introduction of conduits in accordance with the aforescussed prior proposals which involve the heating of a body of fluid in the interior of a sewage pipe or the like. Furthermore, the heating device 13 heats a body of fluid which repeatedly flows through the conduits 5. It goes without saying that the direction of hot fluid flow in the two illustrated conduits 5 can be reversed (e.g., intermittently) without departing from the spirit of this invention. Furthermore, though the stream of fluid which is supplied by the heating device 13 can flow back into such heating device (this is actually shown in Fig. 3), it is equally possible to operate without recirculation of such fluid. Moreover, the pipe 1 need not be and often cannot be horizontal or exactly horizontal, and the heated fluid issuing from the device 13 is or can be discarded once it has been caused to flow through a single conduit 5 if the pipe 1 is designed or required to confine a single conduit 5. The illustrated arrangement with two conduits 5 exhibits the advantage that it permits for optimal utilization of heat for satisfactory setting of hardenable material 3 in the entire strip 4, i.e., all the way between the ducts A and B, particularly an optimum distribution of heat all the way between the ends of the pipe 1.

Additional savings can be achieved if the fluid (such as air and/or water) which is utilized to expand the hose 7 in order to urge the strip(s) 4 against one or more selected portions of the internal surface 9 of the pipe 1 is not subjected to any preliminary treatment (such as heating or cooling). For example, cold (i.e., unheated) water or air can be utilized with advantage to ensure satisfactory abutment of the convex external surface of a sickle-shaped strip 4 against the adjacent portion of the concave internal surface 9 of the pipe 1. Eventual minor leakage of water or air from the hose 7 is of no consequence because the rate of delivery of fluid by the pump which supplies such fluid into the interior of the hose 7 can be readily selected to compensate for eventual minor leakages radially outwardly through the hose. The pump or pumps and the conduit(s) which supplies or supply cold water, cold air or another suitable hydraulic or gaseous fluid into the pipe 1 can be installed at or in the duct A or B. Such parts are omitted in Fig. 3 for the sake of clarity.

The duration of admission of a heated fluid into the conduit(s) 5 by the heating device 13 and the exact temperature of the fluid which is supplied by the device 13 can be determined experimentally or otherwise and depends upon the dimensions of the strip 4, upon the quan-

tity and nature of the heat-hardenable matrix and (if necessary) upon one or more additional parameters. In many instances, such parameters will be selected experimentally and normally depend, to a considerable extent, upon the characteristics of the material of the matrix 3 in the strip 4.

It has been ascertained that the improved method can be practiced with particular advantage when the strip 4 is made of a suitable textile material and is utilized to introduce one or more conduits 5 into otherwise non-accessible or not readily accessible pipes 1 for sewage, gas, water or the like. However, it will be readily appreciated that such method can be practiced with equal or similar advantage in connection with the introduction of conduits into more readily or quite readily accessible pipes, e.g., into sewage pipes in large or relatively large cities, because it is simpler and less expensive than presently known undertakings being resorted to for the introduction of data cables, current conductors and/or the like into water pipes, sewage pipes, gas pipes or other types of pipes.

In accordance with a modification, the expandible hose 7 can be replaced by or utilized jointly with other suitable means for temporarily or permanently urging the strip or strips 4 against one or more selected portions

of the internal surface 9 of a sewage pipe, water pipe or the like. For example, one can resort to a set of boards, panels, laths, planks or analogous rigid or substantially rigid parts (hereinafter called panels) which are inserted into the pipe adjacent the inner side(s) of one or more already inserted strips 4 which contain one or more conduits 5 and are permeated with a heat-hardenable or settable matrix material. This applies irrespective of the exact purpose of the conduit(s) 5, i.e., regardless of whether such conduit(s) is or are utilized to confine information-transmitting wires, electric cables and/or serve other purposes. Still further, the conduit or conduits 5 can serve to convey a gas, water and/or any other fluid medium into the building or buildings M which is or are adjacent the underground path for one or more pipes 1 serving to convey water, sewage, gas or another flowable substance.

The introduction of one or more strips 4 can take place simultaneously or substantially simultaneously with the making and laying of the pipe 1 or at a later or much later date. Such undertakings exhibit the advantage that it is not necessary to carry out extensive digging or excavation work if one or more conduits 5 are to be installed at locations where a pipe having at least one more or less readily accessible portion is already con-

fined in the ground for the purpose of conveying sewage, water, a gas or the like.

The aforesdiscussed advantages of the improved method and of the improved underground pipe or pipes can be summarized as follows: Substantial savings in installation time, cost of equipment and heat energy are achieved due to the novel concept of causing the matrix 3 to set by replacing the admission of necessary heat by a fluid medium in the interior of the hose 7 with the admission of heat by way of the conduit or conduits 5 whose inner diameter or diameters is or are but a minute fraction of the inner diameter of an expanded hose 7. This renders it possible to achieve enormous savings in heat energy and equipment which is utilized to convey a heated fluid in such a way that the fluid can cause proper setting of the material in the matrix or matrices 3 while the strip or strips 4 is or are maintained in requisite position(s) relative to the pipe.

Furthermore, heated fluid (in the conduit(s) 5) is caused to contact only that part (the strip or strips 4) which contains or carries the heat-hardenable material. Thus, it often suffices to cause the heating device 13 to supply a few liters of water, i.e., a small quantity which is sufficient to heat a matrix 3. It is possible to heat one or more small streams of heating

fluid by resorting to a simple gas-operated heater. Such small heater suffices to properly heat a fluid (e.g., water) which is introduced into a conduit 5 to adequately heat and effect a setting of a matrix 3 in a strip 4 having a length of 100 meters or more. It has been ascertained that the material of the matrix 3 in a relatively wide strip 4 can be caused to set rapidly and highly satisfactorily even if the device 13 is caused to admit heated tempering or hardening fluid (such as water) into a single conduit having a small diameter. The utilization of the loop 15 between the neighboring ends of the conduits 5 in the duct B of Fig. 3 also contributes to a highly satisfactory utilization of heat which is supplied to the heating fluid in one of the two conduits 5 in the duct A of Fig. 3.

The provision of the loop 15 exhibits the additional important advantage that the quantity of liquid which must be heated is halved because such liquid exchanges heat with the matrix 3 while flowing from the duct A toward the duct B as well as while flowing (again within the confines of the strip 4 and the matrix 3 therein) in the opposite direction, i.e., back to the heating device 13. Thus, the transfer of heat from the fluid in the conduits 5 to the matrix 3 in the strip 4 is highly satisfactory and contributes significantly to

economy of the improved method. Still further, the admission of heat to the strip or strips 4 can be regulated with a very high degree of accuracy to thus ensure predictable and uniform admission of heat to each portion of each strip 4. Of course, it is also within the purview of the present invention to employ several heating devices (such as 13 or the like); this can even further enhance the uniformity of the heating action upon each portion of the matrix 3. For example, one can employ two heating devices, one in each of the ducts A and B. This not only permits for more predictable heating of each part of the strip or strips but also allows for more economical utilization of the heat energy.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of the above outlined contribution to the art of laying cables, conduits, conductors and the like in underground pipes and the like and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the appended claims.